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MORPHOAGRONOMIC BEHAVIOR OF PROMISING CHICKPEA GENOTYPES (*Cicer arietinum* L.)

Comportamiento morfoagronómico de genotipos promisorios de garbanzo (*Cicer arietinum* L.)

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ABSTRACT. In Cuba, the chickpea is a very appreciated grain in the population's diet because of its high nutritional value, but there are only nine varieties in the national market, so it is necessary to increase the varietal diversity of this species that also allows to substitute imports in a sustainable manner. The study was developed in the National Institute of Agricultural Sciences (INCA) with the purpose of evaluating the behavior of 10 promising chickpea-type Kabuli genotypes, selected from germoplasm introduced from the International Center for Agricultural Research in the Dry Areas (ICARDA) from Syria and the National Institute of Agricultural Technology (INTA), Argentina. Seven quantitative morphoagronomic variables were evaluated: plant height (AP), height of the first pod (AV), number of primary basal branches (NR), number of pods per plant (NV), number of seeds per plant (NS), empty pods (VV) andperforated pods (VH) and the data were analyzed by univariate and multivariate methods of principal components for the set of variables and genotypes and by cluster analysis between genotypes. The results showed that the variability in the studied collection was represented mainly by AV, AP and NS, the latter correlated negatively with the previous ones. A group consisting of six genotypes that showed stability in their morphoagronomic behavior under the conditions of the study was detected, so it is recommended the evaluation of these in superior yields trials.

Key words: arthropods, leguminous, pods

RESUMEN. En Cuba, el garbanzo es un grano muy apreciado en la alimentación de la población por su alto valor nutritivo, pero solo existen nueve variedades en el mercado nacional, por lo que es necesario incrementar la diversidad varietal de esta especie que permita, además, sustituir importaciones de manera sostenible. El estudio se desarrolló en el Instituto Nacional de Ciencias Agrícolas (INCA) con la finalidad de evaluar el comportamiento de 10 genotipos promisorios de garbanzo tipo Kabuli, seleccionados a partir de germoplasma introducido desde el International Center for Agricultural Research in the Dry Areas (ICARDA), de Siria y del Instituto Nacional de Tecnología Agropecuaria (INTA), Argentina. Se evaluaron siete variables morfoagronómicas cuantitativas: altura de la planta (AP), altura de la primera vaina (AV), número de ramas basales primarias (NR), número de vainas por planta (NV), número de semillas por planta (NS), vaneo de las vainas (VV) y vainas horadadas (VH), los datos se analizaron por métodos univariados y multivariados de componentes principales para el conjunto de variables y genotipos y por análisis clúster entre genotipos. Los resultados mostraron que la variabilidad en la colección estudiada estuvo representada principalmente por AV, AP y NS, éste último correlacionado negativamente con las anteriores. Se detectó un grupo conformado por seis genotipos que mostraron estabilidad en su comportamiento morfoagronómico en las condiciones del estudio, por lo que se recomienda la evaluación de estos en ensayos superiores de rendimiento.

Palabras clave: artrópodos, leguminosa, vainas

INTRODUCTION

The chickpea is a legume native to southwest Asia, whose grain is highly valued in human and animal food for its nutritional value (1,2) and it has between 18-25 % of proteins (2,3).

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Its presence in Cuba is the result of the process of culinary transculturation influenced by Spanish cuisine (4) but its consumption has historically depended on purchases abroad, mainly from Mexico, Canada and Spain, which forces the country to import this legume that the high expenditures of foreign currency are added.

Therefore, its production in the country is a valuable contribution to the effort to replace food imports (5) which is based on growing knowledge of the crop, the increase in prices in marketing and low production costs with relationship to other grain species.

On the other hand, its cultivation is not very demanding to water, so that its planting contributes to the adaptation to climate change (6) in localities with a propensity to drought, but being seasonal with a short optimum period of sowing (November-December). is subject to good production planning in order to obtain the harvest before the rainy season (7).

In plant breeding, morphoagronomic characterization has been essential in the identification of desirable traits in individuals destined to be released directly as cultivars or used as gene donors. In this case, the characterization is based on prior knowledge to guarantee the uniformity of the data (8).

In this field, the development of research on an international scale, has favored the obtaining of varieties adapted to tropical conditions, which has allowed introducing in the country, chickpea germplasm of diverse origin, grouped in nurseries of resistance to biotic and abiotic stresses (9-11).

As a result, in the last 40 years a great diversity of genotypes has been evaluated for different stresses (6,9-15). However, so far, only nine varieties have been registered in the official list of commercial varieties: National-6, National-24, National-27, National-29, National-30, National 5HA, Blanco Sinaloa 92, Jamu 96 and JP-94 (16).

Recently, with the execution of agrobiodiversity fairs, which are a tool of participatory plant breeding, promising genotypes have been selected based on the knowledge, tastes and needs of local producers and consumers (11). This could contribute to the diversification of the genetic base of this species and to promote, in the medium term, new local cultivars for their registration in the register of commercial varieties.

The present study aims to evaluate seven quantitative morphoagronomic variablesin 10 chickpea genotypes grown in the edaphoclimatic conditions of the Tapaste locality, in San José de las Lajas, Mayabeque province.

MATERIALS AND METHODS

The research was carried out during the 2011-2012 stage (Figure 1), in areas of the National Institute of Agricultural Sciences (INCA) located in Tapastee town, San José de las Lajas municipality (N 23° 01’and W 82°13’) in Mayabeque province, Cuba, with an altitude of 120 m a.s.l and a soil classified as Nitisol ferralitic lixic (eutric, arcillic, rhodic) (9).

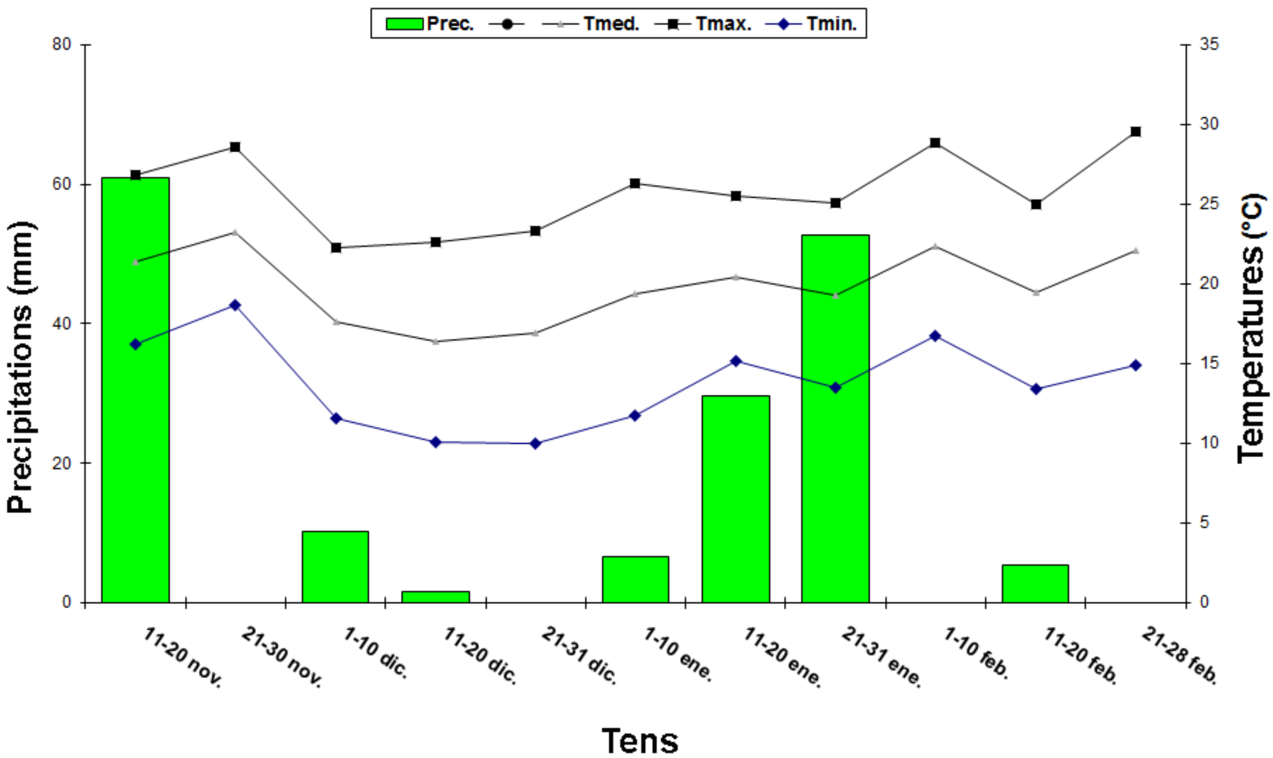

Figure 1. Distribution of average, maximum and minimum temperatures (°C) and rainfall (mm) during the 2011-2012 growing season in Tapaste, Cuba

The temperatures (°C) were registered in degrees: maximum (Tmax), minimum (Tmin) and average (Tmed) as well as precipitation (mm) to observe the climatic variability in the locality during the growing season.

In the moments of lower rainfall, sprinkler irrigation was carried out, with the purpose of moistening the root zone without saturating the soil (7) and favoring the normal growth and development of the crop.

Used material

To develop the work, 10 lines were used advanced chickpea (Table 1) type'Kabuli' (9,10), from the germplasm bank of the International Center for Agricultural Research in the Dry Areas (ICARDA) in the Syrian Arab Republic (9) and the National Institute of Agricultural Technology (INTA), Argentina.

Table 1. Promising chickpea genotypes studied

Nursery	Genotype	Denomination	Origin
Resistence to Aschochyta	Ga-DI- 48	FLIP 02-07C	ICARDA, Siria
	Ga-DI-57	FLIP 03-42C	
	Ga-DI-68	FLIP 03-133C	
	Ga-DI-74	FLIP 04-25C	
Resistence to leaf minera	Ga-DI-120	FLIP 2005-4C	
	Ga-DI-135	LMR 138	
	Ga-DI-141	LMR 150	
Elite Latinoamericano	Ga-DI-169	FLIP05-163C	
Wilting by Fusariosis	Ga-DI-117	ILC1929	
Argentinean	Ga-DI-247	Norteño	INTA, Argentina

The preparation of the ground with harrow was made at a depth between 30 and 40 cm and was fertilized with N-P-K (incorporated into the soil during the preparation).

The plots had an area of 8.75 m^2 and were composed of five rows of 2.5 m long separated by 0.70 m. The seeds were deposited at a depth of 6 cm with a distance of 0.15 m between them with a density of seven seeds per linear meter.

The cultural attention was made according to the technical instructions for the cultivation of chickpea (7). A randomized block design was used with three replicas separated at 0.50 and 1.00 m between plots.

In 10 plants per genotype, seven morphoagronomic variables were evaluated (Table 2).

Statistical analysis

The data was tabulated and digitized using the Microsoft Office Excel 2013 application and in the relevant cases were transformed by means of the expression $\sqrt{(x + 1)}$ to fulfill the assumption of normal distribution.

With the help of the automated package STATGRAPHICS Centurión XV version 15.2.14, the data were processed by univariate and multivariate analysis of main components for the set of variables and genotypes and by cluster analysis between genotypes. The Bonferroni test ($p \leq 0.05$) was used to distinguish significant differences between the means.

RESULTS AND DISCUSSION

Figure 1 shows the difference between decadal precipitations that oscillated between 0 to 61 mm during the investigation, being the decadal average rainfall of 15.17 mm.

Table 2. Agronomic characters, description and measurement instruments for evaluation

	Variables	Code	Description	Measurement
Morphological	Height of the plant	AP	It was measured in field from the base of the soil to the apical end of the main branch, at 45 days after germination	Graduated rule in cm
	Height of the first sheath	AV	Height of the insertion of the first branch with sheath. It was measured, after plucking the plants, from the base of the stem	Graduated rule in cm
Agronomics	Branch Number per plant	NR	Number of primary basal branches	Physical count
	Pods per plant	NV	Harvested pods	Physical count
	Seeds per plant	NS	Quantity of seeds	Physical count
	Vain pods per plant	VV	Quantity of empty pods (no damage by pod worm)	Physical count
	Pods pierced by plant	VH	Number of pods pierced by worm of the pod	Physical count

The minimum and maximum temperatures during the period were between 10 °C to 29.6 °C respectively and the crop withstood daily thermal oscillations (difference between the maximum temperature minus the minimum recorded over a day) (17), between 10 °C to 14.7 °C, suitable for the growth and development of the crop (7).

It is argued that within the climatic variables the thermal and hydric conditions are relevant in the growth and development of the plants (18) and in field conditions its combination with mineral fertilization, genotype and production practices (19), determine the morphoagronomic response of the culture. The morphological and agronomic traits developed by the different genotypes are presented in Table 3 and in general, the average values obtained for each variable correspond to those reported in the literature consulted, in countries traditionally producing this legume in America such as Mexico and Argentina (20.21).

In Table 3 the values of the CV (%) denote the existence of variability in the studied sample that is maximum for VH and minimum for AV.

This variability demonstrates the usefulness of this collection for the evaluation in different productive scenarios, in order to select individuals that are liked by producers and consumers.

With respect to VH, its presence was detected in all genotypes, affecting on average to 12 % of the pods. This damage, of importance in the chickpea crop, is produced indifferently by the larvae of two phytophagous arthropods *Heliothis virescens*, *Helicoverpa zea* (14,15), which are characterized by their mobility, polyphagia, high reproductive rate and diapause (22), both phytophages will pierce the pods to enter them and feed on the seed.

The presence of VH reveals the generalist tendency of these larvae with respect to the trophic resource, since they require a large amount of proteins or amino acids for the synthesis of their tissues (23), which justifies their preference for seeds in their diet, without distinction of genotypes.

In the case of AV, its low CV denotes a high stability that can be attributed to the fact that the expression of this character is genetically determined.

Taking into account the variability detected in the collection (Table 3), we proceeded to the extraction of the main components of the variability through Principal Components Analysis (ACP) which is a descriptive technique that allows studying the relationships that exist between the variables quantitative, without considering a priori, no structure, variables, or individuals (24).

The ACP showed that the contribution of the variables to the variability of the data could be explained from the extraction of two main components (Table 4) which together explained 80.418 % of the total variance. The high percentage of the variation explained by these two components suggests that they contain variables that discriminate well the collection of chickpea studied.

The first component (C1) explained 44.346% of the total variance, and has a positive correlation with AV and AP, both variables were negatively correlated with NS; however, it has been reported that NS is influenced by multiple environmental factors and may be associated with qualitative characteristics that can confer stability in production (21). Although PA has

Table 3. Behavior of the characters evaluated in 10 chickpea lines type Kabuli

Genotypes	Morphoagronomic characters evaluated						
	AP (cm,)	AV (cm,)	NR	NV	NS	VV	VH
Ga-DI- 48	60,25 a	31,50abc	2,05bc	37,80ab	33,55ab	3,35a	2,90bc
Ga-DI- 57	57,00 ab	28,95bc	2,40b	32,90b	38,75ab	3,2a	2,15c
Ga-DI-68	49,00c	28,00c	2,25bc	37,05ab	36,25ab	0,25b	4,85ab
Ga-DI-74	62,25a	34,75a	3,60a	18,20d	18,50cd	0,00	2,80bc
Ga-DI-120	43,25d	30,00bc	2,20bc	29,15bc	28,4bc	0,00	6,40a
Ga-DI-135	48,50c	28,50c	1,55c	20,80cd	15,15d	0,00	3,10 abc
Ga-DI-141	56,50ab	33,00ab	2,35bc	23,25cd	21,65cd	0,00	1,85c
Ga-DI-169	53,50bc	31,50abc	2,15b	46,95a	43,95a	0,55b	1,95c
Ga-DI-247	56,50ab	30,20bc	2,50b	33,55b	30,40abc	0,00	5,45ab
Ga-DI-117	59,25ab	29,25bc	1,95bc	40,40ab	38,75ab	0,00	6,10ab
MG	55,65	30,56	2,30	32,00	30,53	0,76	3,81
DS	0,34	0,12	0,28	0,42	0,62	0,40	0,64
CV (%)	6,05	2,69	5,02	12,04	17,5	10,99	46,84
ES$\bar{x}$	0,11	0,044	0,10	0,13	0,19	0,13	0,20

Means with different letters differ significantly columns for p≤0,05 been frequently used by stakeholders interested in participatory selection of varieties of chickpea (11), this is not the case with AV, perhaps because for the conditions of small local production it is not of interest, but it will be important when it is required to mechanize the harvest, for which it is convenient that the insertion height of the first pod is high enough, to allow mechanized cutting.

Table 4. Own values, eigenvectors and contribution percentage of the variables in components C1 and C2

Main components	C1	C2
Own values	3,104	2,525
Explained variance (%)	44,346	36,072
Accumulated variance (%)	44,346	80,418
Own vectors		
Plant height (AP)	0,478	0,058
Height of 1st pod (AV)	0,534	0,112
Number of basal branches (NR)	-0,121	0,529
Number of pods (NV)	-0,339	0,449
Number of seedss (NS)	-0,465	-0,204
Number of empty pods (VV)	-0,212	0,504
Number of perforated pods (VH)	-0,309	-0,455

The second component (C2) that explained 36.072 % of the variance was positively correlated with NR and VV and negatively with VH. Evidently this component reveals the influence of the ramifications of the plant on the sterility of the pods, which logically conditions a smaller number of pods pierced by the insect when the seeds are absent inside.

On the other hand, nutritional and physiological studies related to vane pods, suggest that several factors are involved with this pathology such as micronutrient deficiency, among them Boron and Zinc (25,26) and salinity (27).

The percentage of vain pods constituted 2.37 % of the total pods produced, but although this data may seem insignificant, it could become a concern in large-grain Kabuli chickpea cultivars, so attention should be paid to this affectation.

Two-dimensional representation or Biplot (Figure 2) allowed five groups of genotypes to be pre-visualized according to their position in space and their proximity to the corresponding vectors. In this component, the genotypes that showed the greatest stability were: Ga DI-117, Ga DI-169, Ga DI-141, Ga DI-135, Ga DI-120 and Ga DI-247. While in C2 were: Ga DI-120 and Ga DI-57.

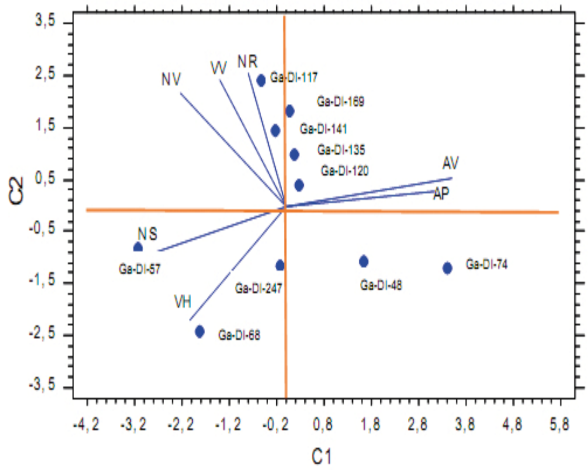

Figure 2. Analysis of main components (C1 and C2). Two-dimensional representation (biplot) of the spatial distribution of the agro-productive variables and grouping of the chickpea germplasm

In the dendrogram resulting from the cluster analysis represent the distances in the similarity of the members of the five clusters formed (Figure 3).

The first cluster is composed the genotypes Ga-DI-48 and Ga-DI-74 both belong to the nursery of resistance to Ascochyta and exhibit the greatest distance in similarity, given by a better behavior of the agronomic variables in Ga-DI-48. Also belonging to this nursery are the contrasting genotypes Ga-DI-57 and Ga-DI-68 that each constituted an independent cluster.

The fourth cluster grouped 50 % of the genotypes, with a heterogeneous conformation since its members belong to the nurseries of resistance to the Leaf Miner, Latin American Elite and Marchitez by *Fusarium* where the minimum distance in similarity between the Ga-DI -135 and Ga-DI-169 genotypes is distinguished for the behavior of the morphological variables (lower AP

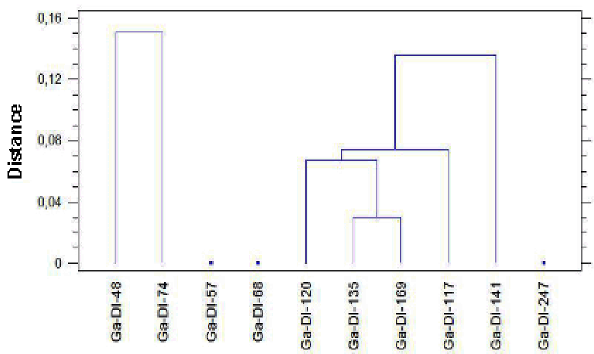

Figure 3. Dendrogram conformed based on the similarities among the five groups of chickpea genotypes studied. Method of close neighbors, Euclidean Square distance

and AV) and high VH. Finally, the Argentine cultivar Ga-DI-247 represented an independent cluster with a high number of seeds per plant and pods drilled (Table 3), both variables with negative values in C2 (Table 4).

CONCLUSIONS

The variability in the studied collection is determined in the foreground by the height of insertion of the first pod, height of the plant and the number of seeds per plant and in the background due to the number of primary basal branches and empty pods per plant. The presence of pods pierced by insects in all the genotypes was detected, while the pod vane was only present in 40 % of them. A group consisting of six genotypes that showed stability in their morphoagronomic behavior was detected.

RECOMMENDATIONS

Because of the morphoagronomic stability expressed, in the conditions of Tapaste locality, it is recommended to evaluate, in superior yield trials, the genotypes: Ga DI-117, Ga DI-169, Ga DI-141, Ga DI-135, Ga DI -120 and Ga DI-247.

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